BEREA SANDSTONE IN ERODED CLEVELAND SHALE[1]

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In Lorain County of northern Ohio occurs the greatest development of the Bedford-Berea unconformity.[2] This unconformity extends throughout other portions of the state.[3] It is found as channels over 100 ft. deep filled with Berea sandstone, as in the Amherst district, and from these pronounced forms declines in prominence to Berea sandstone filled channels 2–3 ft. deep, as that on Indian Creek at Stoneville, Ashtabula County, Ohio; or to a thin sandstone layer of the Bedford eroded away in the center where it crosses Phelps Creek, southeast of Painesville, Ohio.[4]

All of the channels eroded in the Bedford formation have either been confined to that formation, or have started in the Bedford and penetrated into the Cleveland formation which lies below the Bedford. These channels eventually were filled with Berea sand which, on consolidating, formed the Berea sandstone.

The most northerly Berea sandstone in Ohio.—The most northerly occurrence of Berea sandstone is that outcropping on the shore of Lake Erie, two miles east of Vermilion, Lorain County. Here the Berea sandstone extends from the top of a 25-ft. lake-cliff to the water's edge, under which it dips.

As far as the writer is aware, the first and only mention ever made of this body of Berea sandstone was made by E. M. Kindle

[1] Published by permission of the Director of the Ohio State Geological Survey. Read before the Twenty-third Annual Meeting of the Ohio Academy of Science, at Oberlin, Ohio, November 29, 1913.

[2] W. G. Burroughs, "The Unconformity between the Bedford and Berea Formations of Northern Ohio," *Jour. Geol.*, XIX, No. 7 (1911), 655–59.

[3] Charles S. Prosser, "The Disconformity between the Bedford and Berea Formations in Central Ohio," *Jour. Geol.*, XX, No. 7 (1912); Charles S. Prosser, *Geol. Surv. Ohio, Bull. 15*, Fourth Series; H. P. Cushing, manuscript.

[4] Charles S. Prosser, *Geol. Surv. Ohio, Bull. 15*, Fourth Series, p. 277, and B, of Plate XVII, p. 274.

who ascribed its position to faulting.[1] Kindle stated that "in the vicinity of Lorain and for several miles to the westward, the shales [Cleveland] are concealed along the lake by glacial deposits. The shale cliffs reappear again, however, near the mouth of the Vermilion River. Here along the shore east of the river, broad, low anticlinal rolls prevail. These are interrupted by a fault which brings the Berea sandstone down to lake level and beneath which it dips at 45 degrees."

The writer wishes to advance another theory than that of faulting, for the occurrence of the Berea sandstone in the place which it occupies in the Cleveland shale; but first, a detailed description of the geology of this locality is necessary.

The Berea sandstone is composed of massive beds 10–15 ft. thick, with a total height of 20–30 ft. from the water's edge to the highest point of sandstone; the average would be about 25 ft. On the horizontal, the sandstone extends about 100 ft. It dips beneath the lake at an angle of 45 degrees. The stone, itself, is gray, with a moderately coarse grain.

West of the Berea sandstone there is no outcropping of rock for about 200 yds., when the Cleveland shale, that elsewhere forms the lake-cliffs of this region, again comes to the surface and continues westward as the lake-cliff. The covered area is composed of glacial drift.

On the east side of the sandstone, soft, blue-gray shale extends from the lake beach up the lake-cliff, until near the top of the bank the gray shale turns reddish in color. This reddish shale, however, is due to oxidation, for on digging into it, the gray shale is found at a depth of 5 in. from the surface. The red shale is simply oxidized gray shale. The shale is capped by drift, 5 ft. thick.

A concretionary sandstone layer, 1 ft. thick, occurs interbedded in the gray shale at about 20 ft. vertically up the bank when first seen beside the Berea sandstone. The gray shale and the concretionary sandstone layer extend eastward 75 ft. on the horizontal, when they are covered for 125 ft. by drift. At the end of the

[1] E. M. Kindle, "Stratigraphic Relations of the Devonian Shales of Northern Ohio," *American Journal of Science*, August, 1912, pp. 187–213. For reference to quotation see p. 208.

covered area, the Cleveland appears, forming the customary Cleveland shale lake-cliff. Here, where the cliff is formed of the Cleveland formation, the Cleveland shale is thin-bedded with very fine, knifelike edges, black and brittle. Interbedded in this type of Cleveland shale is a 5-ft. bed of soft, thin-bedded, greenish-gray shale, which resembles closely the gray shale beside the Berea sandstone. This greenish-gray shale of the Cleveland is not the same as the shale beside the Berea sandstone, however, for where last exposed the concretionary layer, above mentioned, at this point 12 ft. vertically above the beach, was dipping eastward toward the greenish-gray Cleveland shale 125 ft. horizontally away. But no sandstone layer occurs in the greenish-gray Cleveland, nor in the black Cleveland, whatsoever. The concretionary sandstone layer ceased to exist when the Cleveland was reached. Hence the two gray shales are not the same.

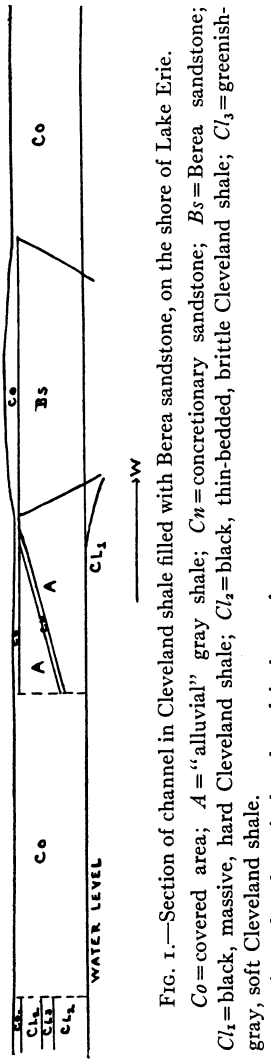

FIG. 1.—Section of channel in Cleveland shale filled with Berea sandstone, on the shore of Lake Erie. *Co* = covered area; *A* = "alluvial" gray shale; *Cn* = concretionary sandstone; *Bs* = Berea sandstone; Cl_1 = black, massive, hard Cleveland shale; Cl_2 = black, thin-bedded, brittle Cleveland shale; Cl_3 = greenish-gray, soft Cleveland shale. Horizontal and vertical scales = $\frac{1}{8}$ inch = 10 feet.

Going once more back to the Berea sandstone, we find at the water's edge, under the gray shale, a jet black, rather massive Cleveland shale, harder and heavier than the Cleveland shale forming the lake-cliffs to the east. This massive Cleveland shale starting 25 ft. to the east of the Berea sandstone dips westward toward the sandstone at an angle which will cause the base of the Berea to be less than 10 ft. below the surface of the lake at the point where it dips under the water. The Cleveland and Berea are within a few feet of each other when the Cleveland dips beneath the lake under the Berea. No

other rock appears to be between the Berea sandstone and the massive Cleveland shale.

The Berea sandstone narrows somewhat in its horizontal dimensions as it descends toward the Cleveland shale beneath. Its sides, though somewhat covered, present the appearance of the sloping sides of a channel, such as is seen where the Berea sandstone fills a channel in the eroded horizon of the Bedford shale. West of the sandstone the lake sands cover the massive Cleveland shale.

One-half mile, slightly to the west of south from this Berea sandstone on the lake shore, gray, moderately coarse-grained Berea sandstone beds one inch to one foot thick outcrop from the bank on the south side of the electric car line. The total height of the exposure is 5–10 ft., and the horizontal distance about 100 ft. The formation is dipping 6 degrees toward S., 18 degrees E., and striking N. 72 degrees E. A few yards to the north, black, thin-bedded Cleveland shale comes to the surface in the ditch beside the New York, Chicago & St. Louis Railroad track. The vertical distance between the Berea and Cleveland outcrops is less than 10 ft. The exact contact is covered.

South of this Berea sandstone outcrop, 100 yds., is an abandoned Berea sandstone quarry, its bottom filled with water and débris. The depth of the sandstone to the water is 20 ft. The pit is about 125 ft. square. The sandstone is gray, moderately coarse grained, beds 8 ft. thick. The top 5–10 ft. of the formation are of thin-bedded sandstone layers, capped by 1–3 ft. of clay. The amount of area underlain by this Berea sandstone appears, from surface indications (for save in the places mentioned the clay drift covers the sandstone), to be 8–10 acres.

Two miles south of this sandstone, along the Lake Shore & Michigan Southern Railroad tracks, the rock is entirely Cleveland shale, and continues to be Cleveland shale until farther south we get the overlying main body of Bedford shale and Berea sandstone. The nearest portion of Berea sandstone to the Berea sandstone in which the quarry is situated, and to that along the lake, is the main body of the Berea formation 2 miles southeast of the quarry, and $2\frac{1}{2}$ miles southeast of the Berea sandstone on Lake Erie.

THE HYPOTHESIS OF FAULTING

Now, if these isolated bodies of Berea sandstone owe their present position to faulting, the downward movement, as measured by present horizons, must have been an approximate vertical displacement of 120 ft., for that is the vertical distance between the base of the nearest portion of the main body of the Berea formation, and the base of the Berea sandstone dipping under Lake Erie. This is a very great throw for this region where all other vertical displacements, as far as the writer is aware, are less than 75 ft. at the most. Also, the presence of several acres of sandstone one-half mile to the south of the sandstone on the lake shore, would hardly have occurred in such quantity through the gentle faulting to which these regions of northern Ohio have been subjected.

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The writer advances the following theory for the formation of these isolated and most northerly bodies of Berea sandstone:

At the same period when the deep channels in the Bedford shale of the Amherst district, $5\frac{1}{2}$ miles to the southeast, were being cut, a stream, as shown by the exposed gray shale and Berea sandstone, cut a channel 175 ft. wide (and without doubt a far greater width could be proven if the outcrops were not covered) into the Cleveland shales.

The Cleveland shale of this district was thus a land area at probably the same time that the Bedford to the south was above the level of the sea. When deposition took the place of erosion, alluvial sediments were deposited in this channel in the Cleveland shale. These sediments later formed the soft gray shale, previously described. The concretionary sandstone bed was laid down at the time these alluvial gray sediments were deposited. As occurs in certain of the Bedford channels, the deposited material slumped toward the sides of the channel, which accounts for the dip of the concretionary sandstone bed toward the Cleveland shale which formed the side of its channel.

Later, the soft alluvial material was worn away to some extent and the Berea sands deposited in the channel thus formed. The

slanting side of the Berea sandstone at its contact with the gray shale of the present day marks the side of this old channel.

THE BEDFORD-BEREA UNCONFORMITY AND THE DEVONIAN-CARBONIFEROUS LINE

Some geologists have questioned the erosion of the Bedford formation prior to the deposition of the Berea, as being of much value in determining the position of the Devonian-Carboniferous line. They argue that the time would be very short indeed, geologically, in order that the soft Bedford shale might be worn away to the extent which we find it, and that the cycle of erosion would therefore be of very slight importance.

Hence, an eroded channel in the Cleveland shale of the magnitude of the one described should help to show that the period of erosion of the Bedford was of much longer duration than was to be inferred by the channels in the soft Bedford shale, for the rather hard Cleveland shale is not especially easy to erode. The time required in the removal of the Cleveland would be far greater than that required in any of the Bedford channels.

Therefore, the interval of erosion of the Bedford prior to the Berea deposition was of greater length than has been shown by any other evidence set forth up to the present time.

Consequently, the Berea sandstone filled channel in the eroded horizon of the Cleveland shale acts as evidence in favor of placing the Devonian-Carboniferous line between the Bedford and Berea formations.